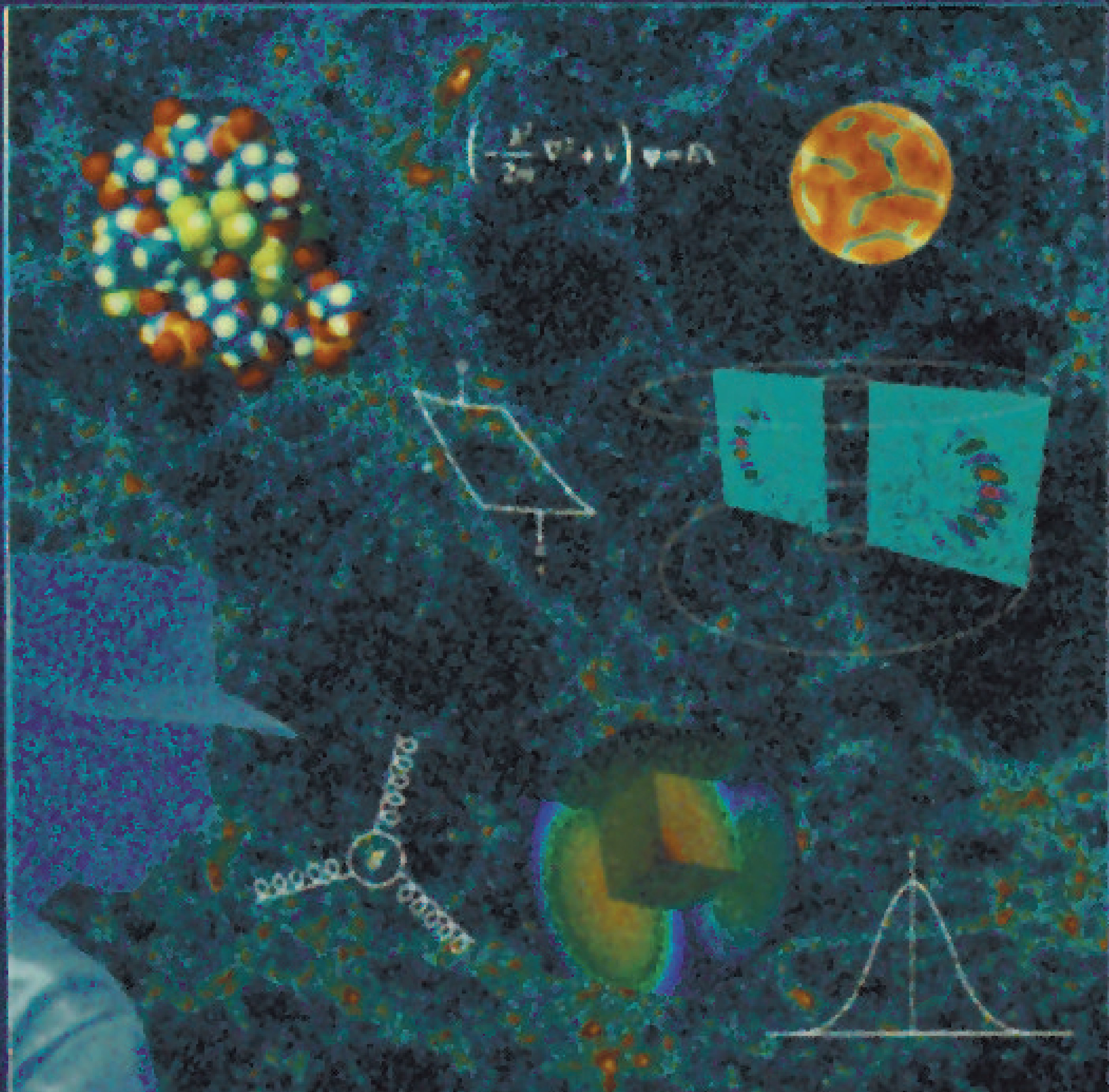
# Los Alamos Science

LOS ALAMOS NATIONAL LABORATORY



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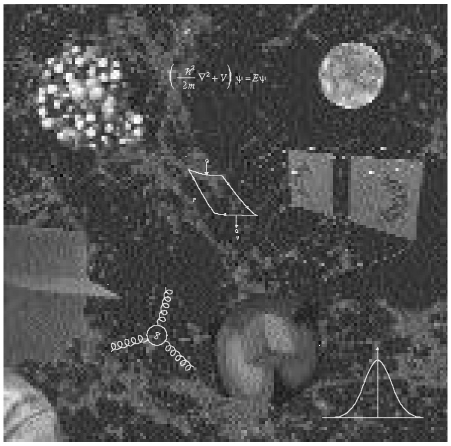
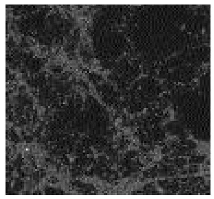
THE LABORATORY'S 50th ANNIVERSARY

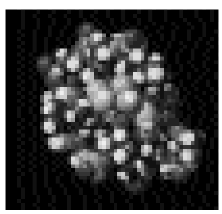



For fifty years, basic research in physics, mathematics, computers, chemistry, and life sciences, combined with ingenious engineering, have been the strength of Los Alamos National Laboratory. Shown on the cover are a few symbols of fundamental concepts in physics and mathematics—the Schrödinger equation, the Carnot cycle, the three-gluon vertex of QCD, and the Gaussian distribution. Also shown are state-of-the-art computer simulations performed at Los Alamos on problems of fundamental interest to science and the nation. High-power computing is opening up more and more complex systems to basic understanding and practical application.



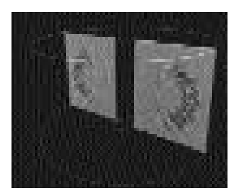
New computer hardware and software tools have enabled scientists, for the first time in history, to incorporate enough physics with sufficient accuracy to simulate the evolution of the universe and the formation of galaxies. The figure shows the distribution of dark matter in the universe from a computer simulation by M. S. Warren of the Laboratory's Theoretical Astrophysics Group and J. K. Salmon of the California Institute of Technology. Their ingenious "treecode" algorithm was able to keep track of the forces among 17 million particles. This algorithm has been picked up by others and adapted to more applied problems.

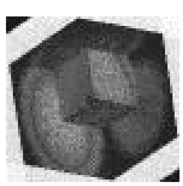
Global modeling of the earth's atmosphere, oceans, and interior is now being undertaken on Los Alamos supercomputers. Shown here is a simulation of convection in the earth's mantle developed by G. Glatzmaier in the Laboratory's Geoanalysis Group. The three-dimensional flow, dominated by viscosity, contains linear regions of downward flow (blue) reminiscent of the subduction zones found on the earth's surface at tectonic-plate boundaries.



The Laboratory's initiative in structural biology is exploiting supercomputers to understand the fundamental interplay between structure and function of biological macromolecules. Depicted here is one of many possible "hairpin" structures of a short DNA molecule in solution as calculated from nuclear-magnetic-resonance data with a new method developed by members of the Theoretical Biology and Biophysics Group. This method involves molecular dynamics and simulated annealing; it was implemented at the Advanced Computing Laboratory.

Research in magnetic fusion, begun in the early 1950s at the Laboratory, is currently an international effort. Progress requires an understanding of turbulence and instabilities in very high-temperature tokamak plasmas. The figure represents a cross section such a plasma showing the instantaneous electrostatic potential in the simulated development of an instability. Numerical simulations of the turbulent plasma provide information that is very difficult to obtain from fusion experiments because the plasma reaches temperatures on the order of 100 million kelvins. The calculation was performed at the Advanced Computing Laboratory at Los Alamos by S. E. Parker and W. W. Lee of the Plasma Physics Laboratory at Princeton University.





Even particle physicists studying the basic forces of nature are employing supercomputers to make predictions with their theories. Shown here is a wave function of a moving pion simulated with lattice quantum chromodynamics (a discrete version of the theory of strong interactions) by R. Brickner of the Computer Research and Applications Group and R. Gupta of the Elementary Particles and Field Theory Group. The contours of the wavefunction would be circles if the pion were at rest, but are distorted by the Lorentz contraction. This research is helping other scientists learn how to exploit the full power of parallel supercomputers at the Advanced Computing Laboratory.

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When the *Los Alamos Science* staff began this volume last September, we perceived it as a great challenge. What aspects would best represent the Laboratory on its fiftieth birthday? The accomplishment of the Manhattan Project and the great scientists who made it succeed inspire all those who come to Los Alamos. That work, those times, that spirit have been superbly documented in Richard Rhodes's *Making of the Atomic Bomb*. The equally extraordinary efforts to build thermonuclear devices, the early efforts to harness the energy of fission and fusion for peaceful uses, and the evolution of the Laboratory into a multipurpose scientific institution were the primary focus of the 1983 issue of *Los Alamos Science* on the occasion of the Laboratory's fortieth anniversary. At that time, many of the great scientists who took part in the Manhattan Project were alive and able to return to Los Alamos to recall for us the birth of the nuclear age.

The fiftieth anniversary is quite different; it marks the end of superpower struggle. The end of the Cold War is a great victory for freedom and for the West, and this volume could have been used to examine the many contributions of Los Alamos to that victory and to other challenges of the past. Given the great changes around the world and at home, however, it seemed more appropriate to just touch on the past and celebrate this anniversary by exploring the directions we can take in the future.

Here at Los Alamos we are experiencing something like an identity crisis, a time of doubt and self-evaluation. What are our missions now that the Cold War is over? What are the new opportunities? What are our strengths, our weaknesses? This volume begins the way we at the magazine began, with a discussion among Los Alamos scientists of those very questions. The round table, "Taking on the Future," suggests the growing pains and internal tensions of the Laboratory as it struggles to adjust to the changes of the last few years.

On one side are the nuclear-weapons scientists, who have always carried out their mission in the silence imposed by the nature of their work. Here they speak candidly about their new challenges and concerns. They face a comprehensive test ban, declining support for their mission, and, simultaneously, the tremendous responsibility of maintaining and managing the nation's nuclear-defense capability in the face of growing threats of nuclear proliferation. On the other side are the scientists working on nondefense projects and basic research. Some of them came from the nuclear-weapons program, but most have no experience with weapons work, nor, for that matter, do they know much about that work. They offered perspectives on new missions and new opportunities.

Though the separation between the two cultures is evident in the round table, their futures are inextricably tied together. As the opportunity to design and test weapons disappears, the weapons program will depend more and more on the basic-research side of the Laboratory for ideas, skills, and new talent. On the other hand, the basic-research effort will remain dependent on the strength of the weapons program. In the past, basic research has been supported primarily by the major applied programs at the Lab, of which the nuclear-weapons program has been by far the largest and best funded and will, in all likelihood, continue to be so for many years. The synergism between the two sides must grow, and together they must find new missions. Those efforts will be aided by the continuous interplay between basic and applied work and the ongoing interaction among the wide spectrum of disciplines that has always characterized the Laboratory.

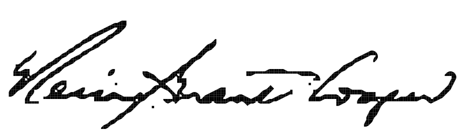
Most refreshing in the round table as well as in all the articles that follow is the great display of diversity. As Edward Teller points out in "The Laboratory of the Atomic Age," the Los Alamos tradition of tolerance for widely different views began with Robert Oppenheimer and continues to this day. It was essential then and is essential now in this community of intensely creative individuals with diverse views, talents, and styles. Diversity and creativity are not easy to manage, but they are our hope and our strength in meeting the growing complexity of science, of our missions, and of the world.

"The Stewardship of Nuclear Weapons" emphasizes another essential hallmark of the Laboratory, its ongoing commitment to service. The men and women who work on nuclear weapons were drawn to that field not just by their fascination with the complexities of the physics and the challenges of designing and testing but also by their patriotism. The nation is asking them to change how they work, to go from the production of the new to the maintenance of the old, a tall order for creative people. Their response, outlined here, is no less than a redefinition of the entire scope and nature of their activities to meet the changing contingencies without, they hope, compromising the nation's nuclear capabilities. A particularly welcome result of their new situation is the opportunity to meet and collaborate with their Russian counterparts on unclassified projects of mutual interest. We also had the pleasure of meeting Russian scientists from Arzamas-16 on their visit to Los Alamos and of interviewing Alexander Pavlovskii, a long-time colleague of Andrei Sakharov. Pavlovskii's comments on the experience of the Russian weapons scientists, which close this section, quietly portray the drama of the Cold War in the Soviet Union and the difficult period that has followed.

"Science and Innovation," a sampling of the dazzling array of research at Los Alamos, exhibits the enormous energy, enthusiasm, and creativity of our scientists. The uncertainties of the future notwithstanding, they all put their hearts into their writing and were inspired on this special occasion to explain not only their latest advances but also the philosophy behind their work, its roots in their beloved disciplines, and the exciting opportunities they see in the future.

This issue closes with two pieces on science policy. The first places the Laboratory's work in historical perspective. The second, by our director, lays out the major directions for the Laboratory's future and many vehicles for our contributing to new national priorities in the civilian and commercial sectors.

It was a great pleasure to work with everyone who contributed to this issue. The volume does, I believe, clearly demonstrate why Los Alamos will continue to be what it has been for fifty years—a national treasure.



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